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Daily feeding regimen impacts pig growth and behavior

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HIGHLIGHTS

- Feed regimen did not alter feed efficiency in pigs.
- Pigs fed twice daily ate less and grew slower than pigs fed free access.
- Pigs fed twice daily had a lower final fat:protein than pigs fed free access.
- Feed regimen altered eating frequency and duration.
- No feed regimen differences in standing, sitting, and lying activity were observed.

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ABSTRACT

A primary swine production goal is to increase efficiency of lean tissue gains. While many swine production systems currently utilize *ad libitum* feeding, recent research suggests that altering feeding patterns may impact feed efficiency. Therefore, the objective of this study was to compare two feeding patterns and evaluate their impact on whole body tissue accretion, feeding behavior and activity in growing pigs. Forty eight individually housed gilts (55.9 ± 5.2 kg on test BW) were assigned into one of two feeding treatments: 1) Free access to the feeder (Free Access) or 2) twice daily access where gilts were allowed to eat *ad libitum* between 08:00–09:00 h and again from 17:00–18:00 h (2×). Pig performance was recorded weekly for 55 days and average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F) was calculated. Body composition was assessed in 12 gilts per treatment using dual X-ray absorptiometry (DXA) at day −3 and 55 of treatment, and tissue accretion rates were calculated. Gilt behaviors were assessed via video analysis during week 7 and included time spent eating, feeding rate, enrichment interaction, postural changes, standing, sitting, and lying behaviors. Gilts fed 2× had lower ADG and ADFI compared to Free Access gilts ($P \leq 0.01$); however, no treatment difference in G:F was observed ($P = 0.83$). At day 55 gilts fed 2× had a lower fat:protein compared to Free Access gilts ($P = 0.05$). Fat, lean, and protein accretion rates were lower in gilts fed 2× compared to those fed Free Access ($P = 0.01$). Gilts fed 2× ate less frequently and for a shorter duration of time, interacted with enrichment more frequently ($P \leq 0.005$), and tended to have less frequent postural changes compared to Free Access gilts ($P = 0.08$). No treatment differences were observed in duration of time spent standing, sitting, or lying ($P \geq 0.39$). Although feed regimen did not alter feed efficiency, these data indicate that twice daily feeding reduced gilt adiposity and growth without altering the pig's behavioral expression of hunger. Therefore, twice daily feeding may be a method of increasing percent of lean tissue without negatively impacting gilt welfare.

1. Introduction

Multiple feed management systems are utilized in the U.S. swine industry. In grow-finish systems, *ad libitum* feeding is the most common regimen, whereas drop feeding and electronic sow feeders are commonly used for restrictive feeding of gestating sows. Differences in feed management systems are typically driven by production goals, i.e. maximal growth in grow-finish systems, reaching ideal bodyweight and condition at first mating in gilt developer units (GDU), and maintaining ideal body condition in gestating gilts and sows. While production goals vary across production stages, an overall swine industry goal is to improve feed efficiency and thus profitability. Furthermore, animal welfare is an important producer and consumer interest and the impact of feed management on pig hunger is a primary concern [1].

Feeder visit frequency varies across individual pigs, in part due to genetics [2,3], feeder design, feeding program and social status [4]. Feeder visit frequency has been related to genetic selection for feed efficiency, with more feed efficient pigs visiting the feeder fewer times compared to less feed efficient pigs [2]. However, studies manually altering feeding patterns have reported conflicting results related to feed efficiency and

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changes in body composition [5–7]. Therefore, in order to provide recommendations for a feeding system that is most beneficial for production goals, more conclusive information is necessary.

Surprisingly, few studies have related pig behavior to nutrient utilization and growth. Therefore, understanding how feeding regimen and efficiency of lean growth impacts pig behavior is important, as feeding behavior and activity can be indicators of hunger and satiety [8,9]. Furthermore, behavior can partially explain differences in energy expenditure [10]. Schneider and colleagues [7] and Brouns and colleagues [11] reported that pigs fed fewer times spent a shorter duration of time eating. However, these authors reported conflicting pig activity results.

Therefore, the objective of this study was to compare two feeding patterns and to evaluate their impact on gilt nutrient utilization and whole body tissue accretion, feeding behavior and activity. Our second objective was to relate gilt feeding behavior and activity to nutrient utilization and whole body tissue accretion. Our hypothesis was that gilts fed free access would utilize nutrients less efficiently for lean tissue gains, spend more time eating and be more active compared to gilts fed less frequently. We also hypothesized that gilt behavior would correlate with nutrient utilization and whole body tissue accretion. This study utilized 56 to 114 kg BW female pigs (gilts) as a model for evaluating two feeding patterns. These results can therefore be applied to gilts within grow-finish systems and GDUs.

2. Materials and methods

All experimental procedures were approved by the Iowa State University Animal Care and Use Committee (IACUC# 8-14-7851-S). This work was conducted at Iowa State University from October to December 2014.

2.1. Animals and housing

Forty-eight crossbred female pigs (gilts; 55.9 ± 5.2 kg on test BW) were blocked by body weight into two feeding treatments: 1) Free access to feeders (Free Access; $n = 24$) or 2) twice daily feed access (2×; $n = 24$). The 2× treatment allowed gilts to eat *ad libitum* between 08:00–09:00 h and again from 17:00–18:00 h. The 2× feeding treatment was chosen as an alternative regimen to Free Access feeding based on the results of Young and colleagues [2] who observed that more feed efficient pigs had fewer feeder visits at the two peak meal times that occurred between 8:00–10:00 and 14:00–18:00 h. All gilts received either feeding treatments for 55 days and this will be referred to as 7 weeks. Both treatments were fed the same corn-soybean mash diet in three phases that met or exceeded NRC [12] requirements for this size of pig. The phase 1 diet was formulated to contain 13.88 MJ/kg metabolizable energy (ME) and 0.96% standardized ileal digestible (SID) lysine. The phase 2 diet was formulated to contain 13.89 MJ/kg ME and 0.87% SID lysine, and the phase 3 diet was formulated to contain 13.92 MJ/kg ME and 0.78% SID lysine. Diet phase changes were made when pigs individually reached specific BW; therefore, phase 1 diet was fed initially through 70 ± 10 kg BW, phase 2 diet was fed from 70 through 90 ± 10 kg BW, and the phase 3 diet was fed from 90 ± 10 kg BW through the end of the study.

All gilts were housed in individual pens measuring 2.21 m long × 0.61 m wide within nose to nose contact with each other. All pens were located within one climate controlled room, set to the thermoneutral requirements for this size of pig. An electronic recording device (HOBO Pro v2, temp/RH, U23-001, Onset Computer Corporation, Bourne, MA, USA) was located within the room to record ambient temperature (°C) and relative humidity (%). The mean (±S.D.) ambient temperature was 19.9 (±1.2) °C and relative humidity was 60.8 (±5.7)%. Lights were on a 12:12 light dark cycle with light hours from 7:00–19:00 h. Each pen was located on slatted concrete flooring and contained a polypropylene rope tied to an overhead bar for environmental enrichment, a water nipple, and a single-space feeder with a lid. To achieve the 2× feeding treatment, feeders were latched to prevent gilts from accessing feed during non-meal times (Fig. 2.1). Gilts were acclimated to this housing for three days prior to the commencement of feeding treatments. Within the same room, gilts were stalled next to other gilts of the same treatment and a solid visual barrier was located between pens separating Free Access and 2× treatment to avoid synchronized feeding [13].

2.2. Performance

Gilt body weight and feeder weights were measured weekly over 7 consecutive weeks. These data were used to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (gain:feed, G:F). Feeding rate was determined during week 7 for each treatment by measuring feed disappearance from feeders at 8:00, 9:00, 17:00, and 18:00 h. Feeding rate was calculated by dividing feed intake by the duration of time spent eating (see Section 2.4).

2.3. Whole body composition and tissue accretion

Longitudinal whole body composition was assessed in 12 gilts per treatment using a Hologic Discovery A Dual X-ray Absorptiometry (DXA) machine (Bedford, MA, USA) before (day −3; initial scan) and after (day 55; final scan) the 7 week performance period. To ensure that gilts remained stationary during DXA scanning, gilts were anesthetized using xylazine (4.4 mg per kg; Anased, Lloyd Laboratories, Shenandoah, IA, USA), ketamine HCl (2.2 mg per kg; Ketaset, Wyeth, Madison, NJ, USA), and tiletamine HCl and zolazepam HCl in combination (4.4 mg per kg; Telazol, Wyeth, Madison, NJ, USA) prior to the initial DXA scan. Immediately prior to the final DXA scan, gilts were humanely euthanized by captive-bolt and scanned. The DXA output provided information on whole body bone, fat, and lean tissue mass. Scan data was corrected using internally built calibration curves for pigs using the following regressions: Live weight, $y = 1.0822x - 1.826$, $R^2 = 0.997$; Fat, $y = 0.9515x - 1.06$, $R^2 = 0.9308$; Bone mineral ash, $y = 2.1473x - 0.1411$, $R^2 = 0.9219$; Lean, $y = 1.0668x - 0.1411$, $R^2 = 0.9909$; Protein, $y = 0.2206x - 0.6611$, $R^2 = 0.9758$. Where x = DXA results and y = chemical proximate on an empty whole body (i.e. no luminal, urine or gall bladder contents). These calibration curves where built as described by Suster et al. [25]. Tissue accretion was calculated by determining the net change between final and initial body compositions, divided by the days between scans.

2.4. Behavior

To assess gilt behavior, eight color cameras (Panasonic, Model WV-CP-484, Matsushita Co. LTD., Kadoma, Japan) were positioned above the pens. The cameras were fed into a multiplexer using Noldus Portable Lab (Noldus Information Technology, Wageningen, The Netherlands) and time-lapse video was collected onto a computer using HandyAVI (version 4.3, Anderson's AZcendant Software, Tempe, AZ, USA) at 10 frames/s. Video was continuously analyzed during week 7 for 36 h starting at 7:00 h and ending at 19:00 h the following day. Video observations were collected using the Observer software (The Observer XT version 10.5, Noldus Information Technology, Wageningen, The Netherlands) by four trained observers who had intra- and inter-observer reliabilities of ≥80%. Eating, postural changes, standing, sitting, and lying behaviors were collected for all 48 gilts and enrichment interaction was collected on 23 gilts (2× $n = 12$ and Free Access $n = 11$; Table 1).

2.5. Data analysis

All data were evaluated for normality using the Shapiro-Wilk test and Q-Q plots using SAS (version 9.4, SAS Inst., Cary, NC, USA). Performance, body composition, and tissue accretion data were normally